York, would not only be of great interest to the geologist but of direct economic importance to all interested in shipping, harbor improvements, reclamation of land, etc. The records of deep wells and soundings in the salt marshes that have a bearing on this subject are tabulated in the paper published by the Academy. On the Newark Meadows and in Newark Bay the rock bottom is from two to three hundred feet below the present surface. East of Bergen Hill soundings show a depth to rock nearly as great. The following list taken from the tables mentioned above, give some of the soundings on the borders of the deeply eroded channels of the Hudson, East and Harlem rivers :

Hudson River, foot of 23d st., 250 feet from the east building line of the river street	175 ft. to rock.
Hudson River, foot of Bethune st., 20 ft. W. of bulkhead line	176 ft. rock not reached
Hudson River, pier 60 (old No.), 20 feet W. of bulkhead line	175 ft. to rock
East River, N. Y. Tower of Brooklyn Bridge	107.4 ft. to bed rock
East River, Brooklyn Tower of Brooklyn Bridge	88 " "
East River, pier 41, N. Y, 200 ft. from the building line of South st.	91 " "
East River, pier 18, 200 ft. from the building line of South st	60 " "
Harlem River at High Bridge, centre of river	70 ft. rock not reached
Harlem River, Madison av. Bridge, centre of river	75 " " "
As shown on the Coast Survey Charts of New York harbor, the water in the Hudson off Castle Point is	50–65 ft. deep
In East River, W. of Blackwell's Island	107 " "
In East River, at Hell Gate	121 " "
" " near Ward's Island	170 " "
In New York Harbor	60–80 " "
In the Narrows	60–116 " "
In the Kill Von Kull	25–54 " "
In Arthur's Kill	20–35 " "

These measurements, none of which give the maximum depth of the old channels, clearly prove that the drainage system about New York was at no very distant time several hundred feet below the present water surface. It might be shown with equal certainty that we are living many thousands of feet below what would have been the surface of the county had there been no erosion.

THE SOULS OF PLANTS AND ANIMALS.

By the Rev. Dr. Thomas Hill.

The only things concerning which we can arrive at absolute certainty are space, time and spirit. Their existence and some of their attributes are announced in every act of self-consciousness. Their existence and attributes are not matters of inference, but of direct sight. Matter, on the other hand, can substantiate its existence only by inference from these primal truths of space, time and spirit. All natural sciences are matters of mere deduction from the data furnished by mathematics and mental philosophy. All the business of life, (our manufactures, commerce, history), relating primarily to material things, rests in the same way, ultimately on truths of space, time and spirit; that is on mathematics and philosophy. The conclusions at which we arrive in the historical and natural sciences are therefore more or less probable; and the probability may reach a degree that is practically indistinguishable from certainty. I am practically as sure that this sheet of paper would burn if I held it in the gas jet, as I am that two straight lines cannot enclose a space. Nevertheless the first truth is a matter of contingency and probability, the second of absolute knowledge. These truths of absolute certainty, of direct intuition, concerning space, time and self-conscious mind, are not contingent; they remain true, though heaven and earth pass away, and the perception of them is that which puts the stamp of immortality on the human mind.

But in addition to these fields of direct sight, the three fields of truth outside the conscious mind, are of the highest value. In the first place the certainty of the existence of other minds, is as near absolute certainty as it is possible for a truth of inference to be. That there are other men about me, and there is an Infinite Mind above us all, are truths which are practically as certain as the axioms of geometry. In the second place my fellow men are acting and have been acting, thinking, writing, painting, composing, legislating, warring and making peace, manufacturing and inventing for thousand of years; and the study of their history is the richest and most fruitful method of developing my own powers, and learning to know myself. In the third place the field of space and time in which their history is cast is full of this wondrous matter, which gives them their opportunities, their means, their tools; without it mental or moral life is inconceivable; consciousness itself is awakened to activity only through contact with matter; space and time are visible only through motion as a phenomenon of matter.

Here then is a great object of study, worthy of man's thought. Socrates was fearful lest Plato should spend too much time on questions relating to the measurement of matter; Dr. Johnson in the Rambler carried Socrates's implied censure much farther than the old philosopher himself would have done. Swift in his voyage to Laputa satirizes the students of physical science; the newspapers of our own day indulge occasionally in laughing at the technicalities of the scientific man; even men as wise as the Autocrat of the Breakfast Table utter occasional words of disparagement in speaking of scientific pursuits. But Plato's geometry has done as much for the intellectual and purely spiritual development of our race as Socrates's morality; and the physical philosophers of Europe, during the past three centuries, have, despite their own frequent ignorance of spiritual things, been of immense advantage to spiritual philosophy.

The relations of space are the earliest object of our scientific research. The first really intellectual ideas in a child's mind are those of geometric form. Hence all sciences that flow directly from geometrical relations are likely to be earliest developed. Mechanics preceded chemistry, and the classification of plants and animals by their outward forms preceded the knowledge of physiology, animal or vegetable.

Let us look then a moment at the geometrical study of material things, and see what it involves. Material forms suggest to the child the consideration of shape. He early learns to abstract form from the outward things and compare likeness in form only. He is but a few months old when the smallest drawing of a man, a dog, or cat, is recognized at sight. In a few years he takes the further step of looking by reason beyond the picture of imagination, and seeing the unimaginable realities in space itself. He conceives, for example, a sphere. But that portion of space which lies in a given sphere, surrounding a given point, has no properties by which it is distinguished from other parts of space. This is the Leibnitzian argument by which some modern writers would disprove the existence of space; that its parts are indistinguishable and therefore coincident. But the geometer answers: No! by an act of mind I seize upon any point of space and hold it as the centre of any sphere I wish to consider. When he has thus seized upon and considered a portion of space, bounded and separated from the surrounding space, by an act of his pure intel-

lection, he can communicate his thoughts to his fellowmen in either of two ways; first, scientifically by the medium of conventional symbols or language; and second, artistically, by a model or a drawing. This second method reaches a larger audience. What I write concerning a sphere, for example, can be understood only by those who have learned the language in which I write. But if I illustrate my propositions by good drawings or good models, the thought will be grasped by persons unlearned in mathematics—and persons of all nations, whether they understand English or not.

A form or model is therefore the clearest and most complete statement of a mathematical truth. Nor can a person give a more convincing proof of his understanding a truth than his ready and accurate drawing of an original diagram illustrating it. When we see material particles, the fine particles of crayon, for example, on the blackboard, obeying geometrical law, we recognize at once the expression of geometric thought. Law is a mental reduction of particulars to mental order. A geometric locus is a space in which each point is mentally referable to a single proposition; that is, a space in which the position of every point can be mentally grasped and defined by giving properly the position of one of them. When therefore we see numerous particles of matter conforming to a geometric locus, we are forced to believe that that mass of matter was moulded, directly or indirectly, by a mind which comprehended the law of the locus; and in the moulding of it, enounced the condition which defines the position of its points. The enunciation of a thought can come only from a mind comprehending that thought; and the formation of a geometric figure is the clearest enunciation of a geometric thought.

In the physical forces, therefore, which govern inorganic matter, is revealed the existence of a guiding intellect, since the forces are constantly producing perfect geometrical forms or leading to harmonious arithmetical relations. If we are forced to believe that gravity and chemical differences and chemical affinities inhere in matter, we must still, from the geometrical and algebraical powers exhibited by these forces, believe that they were bestowed upon matter by an intelligent power, who oresaw and comprehended their effects. The study of the natural sciences might otherwise well be given over to the reproach of Dr. Johnson in the Rambler, and Swift in the voyage to Laputa. Without a faith that law lies hidden in the material world, all the efforts of scientific explorers would be paralyzed; and without faith that that law is the choice of infinite wisdom, and adapted perfectly to fulfil the purposes of infinite love, the success of the scientific explorer in discovering it would be robbed of its highest and peculiar value.

In fact, the physical forces governing inorganic matter, acting under definite laws, and tending towards a state of stable equilibrium, nevertheless show in the intellectual, the geometrical and algebraical nature of those laws, a spiritual origin; they show that, however independent of will we may now conceive them to be, they nevertheless are the embodiment of thought; and we know of no way of embodying thought without a volition.

But if the Creator has thus stored in crystallizable matter, in a manner transcending all our thoughts, forces which carry out His geometrical and algebraical conceptions, much more marvellous and beautiful are the modes in which he has imparted to the souls of plants and animals (if I may thus extend the use of the word soul) the power of carrying into execution more complicated geometrical and algebraic plans.

For in every organized being, plant or animal, there is a guiding principle which we may call, if we please, a soul, which causes the forces of matter no longer to act under laws tending towards stable equilibrium, but under a variety of laws, different in each species, tending not towards stable but towards unstable equilibrium. This guiding principle has in itself no forces. The most careful investigators of the phenomena of organic growth fail to find any evidence of vital *force*, although there is abundant evidence which must convince the most careless observer that there is in organized growth a vital *guidance* of force peculiar to each species of plant or animal, which I cannot conceive as inherent like the physical forces in matter and which I therefore, must attribute either directly to the Deity, or to an animal or vegetable psyche, empowered by him to carry out these higher geometric forms, just as in each species of matter he has implanted the ability to carry out the simpler geometrical forms of crystals.

There are those whose philosophy differs from mine, and who hold to the opinion that the vital guiding principle in organic growth, and even the rational soul of men and animals are inherent in matter, in the same manner as the forces which they guide are inherent in matter. According to this philosophy the vital principle and the rational principle, inherent in matter, are usually latent and are brought into operation only under peculiar combinations of circumstances.

Now even should we grant the soundness of this view, I should still find it necessary, for the explanation of the logical series of vegetable and animal forms, to suppose that this universally diffused vital principle originally sprang from an intelligent self-conscious being who comprehends the laws of geometry perfectly; and who has expressed certain of his geometric thoughts through the psyche or soul of plants and animals, whether we suppose that psyche diffused but latent through all matter, or confined to the organisms in which it is patent.

The nature of this psyche, of course, transcends our knowledge. We recognize it only through its operations; and consciousness aids us in our attempts to understand it only so far as to show that its effects are intellectually identical in geometric form with the product of our geometric imagination. But we cannot suppose the psyche of the plant or animal conscious of all the thoughts which it develops, since we, whose psychical development is evidently vastly higher than that of any other terrestrial beings, are not conscious of the geometric law of our own bodies, which our souls unconsciously fulfill; not only during the period of our growth, but daily as we supply by nutrition the daily waste of the frame.

The fact that the plant or animal may, without the exertion of any mechanical force, guide the forces of electricity, and light and heat and chemical affinity, to the building of peculiar forms imprinted on its own soul, may receive a coarse illustration from the operations of the steam-engine in which, by delicacy and accuracy of workmanship, the direction given to the power can be changed by a force infinitesimal in comparison to the force exerted by the engine. The chemical forces which govern the organogens in their compounds are always the same, but the results vary for each individual plant or animal, and the law which those results indicate is different for each species. The forces, building out of these few simple elements so great a variety of forms, are tremendous in their energies, and their existence is forced upon the attention of the naturalist; but the vital force, if such a thing exist, which guides these tremendous powers and determines what result they shall bring to pass, has eluded the sight of the most careful and accurate observers. The nicer the investigation into the phenomena of organic form, the more wonderful do the results appear. The persistence of type, for example, through successive generations for many thousands of years, and the very evident transmission of all physical and psychical characteristics from the male parent to the offspring, how utterly inexplicable upon any gross material theory, when we reflect that from the male parent no

matter passes into the offspring, excepting the fluid contents of a microscopic cell strained through its walls and through the walls of the ovule or ovum! Through this infinitesimal quantity of fluid, filtered through this infinitely close double filter, there passes, in some way, a law of form, and a law of mental and physical idiosyncrasy which is stamped upon the whole terrestrial being of the offspring, bending all the untold energies of gravity and of chemical and electrical attraction, to its own particular whim. Through the whole terrestrial life of the offspring do I say?—yes, and I may include in that word offspring sometimes the whole progeny for a thousand generations. The conscious part of the soul is still less known. Its presence is one of the characteristics of animal as distinguished from vegetable life, and the investigation of its comparative development in different tribes of animals is the most valuable part of the field of natural history.

The soul of the plant is presumed to be unconscious. The phenomena of motion in the sensitive plants, and in the efforts of all plants to throw their leaves to the light and their roots to the richest spots in the soil, are supposed to be as unconscious as the contraction and dilatation of the pupil of the human eye. In that dilatation and contraction there is action adapted instantly to circumstances, and so long as the eye is healthy, with unerring promptitude and accuracy. An observer of the human animal might quote this as evidence of the wisdom of man. But on further thought he might see in the very fact that the action is unerring, evidence that it did not depend on the conscious volition of a finite being. And we, men, know that it is a movement of which we are absolutely unconscious.

In like manner it is presumed by the majority of investigators, that all the movements of plants are made with absolute unconsciousness on the part of the plant, and that plants have in short no consciousness whatever, either of their own existence, or of the existence of a world about them. Now it does not follow that on this account the plant is to be studied in its physical relations alone. It has psychical relations also, of the greatest interest to a true enthusiast in botany. The gardener and the botanist constantly speak of the feelings and tastes of plants, and of their moral qualities—indeed some plants have been named from moral nature, as, for example, Rumex patientia, and Carduus benedictus, the patient dock and the blessed thistle—while others have moral epithets that have become as familiar as their names, as, for example, the modest violet and the flaunting poppy.

The geographical distribution of plants will, I think, be found to depend upon something which eludes our study of the external conditions; something besides that physical struggle for life which the English naturalists see in every part of the animal and vegetable kingdom, as though the poor in those kingdoms were oppressed by unjust and impolitic laws impeding the distribution of land, as they are in the kingdom of Great Britain. There is also what may be called a choice in the plants, not implying by that language any consciousness in the plant, but simply affirming that its flourishing here or perishing there, depends in a great measure upon an idiosyncrasy of constitution, making it sensitive to physical changes that can be measured neither by the thermometer, barometer, hygrometer, electrometer nor chemist's balance. The mayflower of New England, called elsewhere trailing arbutus, will adapt itself, when it chooses, to clay or sand, to deep shaded woods or to sunniest hillsides; and I never saw it so flourishing as once in a peat meadow over which it was slily creeping from a sand bank on its edge. But take the plant up with never so much care, and with never so large a sod of unbroken earth about its root, and transplant it where you will, and it is a hundred to one that it dies in a twelvemonth of a broken heart, pining for its old home. Some of these freaks have been explained by the discovery that some plants are semi-parasitic, stealing from the roots of others a part of their food, and therefore incapable of living except in the presence of their patrons,—but many remain yet unexplained.

It sesms to me, however, very plain that the souls of plants, that which makes the difference between a plant living in the forest, and the specimen in the herbarium, that which guides the forces of nature to the building of the plant, and which turns its leaves to the light, is worthy of study in all its relations. It is a depository of divine thought, deposited there ultimately for our instruction as one of its final causes and therefore worthy of the most careful attention.

The intellectual and moral development of animals is also doubtless governed by a plan. The difference between the dull oyster and intelligent, affectionate dog, is as much the result of a plan, or thought, of the Creator, as is the difference of their forms. The horse and the ox are as admirably adapted to domestication by their mental as by their bodily gifts. All the instincts of all animals are adapted to their organization and to the nature of the world and of other animals among which they are placed.

Even should we suppose that the mental power of animals is the result of their organization, that is to say, even if we should suppose that mental power is latent in matter, and simply rendered active by organization, we should be compelled, upon a thorough study of the mental development of animals, to admit that their souls can be classified upon a logical plan, just as their forms can be; and we should be forced to admit, that this latent soul in matter is capable not only of organizing matter according to a logically developed series of forms, but of eliminating out of its own totality separate minds in a progressive series logically connected.

The very great importance of this study of comparative psychology, of becoming acquainted with the mental and moral characters of animals, is obvious. Many attempts to found a science of comparative psychology have been undertaken. But the field is vast, and the progress of the survey slow. At the Baltimore meeting of the American Association for the advancement of Science, Dr. Weinland proposed a method for this new science, ingenious and sound, but by no means exhaustive. He lays down nine fundamental principles; first, that the distinguishing mark of an animal is its consciousness of an outer world; secondly, that this consciousness of an outer world is the fundamental principle of the soul of animals; thirdly, that the consciousness of self results from and is proportioned to the consciousness of the outer world; fourthly, the degree of psychical development can be judged from the degree of development of the consciousness of an outer world; fifthly, this may be judged from the development of the organs of that consciousness; sixthly, these organs are of three kinds, those receptive of sensations, reflective organs and the organs of voluntary motion; seventhly, we may depend in comparative psychology mainly upon a study of the organs of voluntary motion; eighthly, these motions may be divided into two classes, those which refer only to the animal himself, and those by which he would hold communication with other animals; ninthly, man stands at the head of all animals, since his voluntary motions are not only more numerous and perfect than those of other animals, but because through machinery he increases vastly the number of his organs, runs upon the locomotive, talks through the printing press and telegram, and shows us what is most distant through the telescope and stereoscope.

But it is impossible for us to understand any of the phenomena of consciousness save through an appeal to our own consciousness. The mere investigation of the

organs of an animal and its movements can give no true knowledge of the soul of an animal to one who is incapable of analyzing carefully the phases of his own consciousness; nor would the student who is the most thorough master of the analysis of his own thought and feeling, be able to understand the souls of animals, did not the human spirit contain in itself the germ of every power of every terrestial creature. The disposition to attribute to others and to animals the feelings which we should have, were we in their circumstances, although it may mislead the student both of human and of animal life, is nevertheless an essential to successful study. It is impossible for us to understand beings either higher or lower in the scale than ourselves, except as they in some degree resemble us. Our knowledge of ourselves must keep equal pace with our knowledge of other beings; else we have no knowledge of either.

To recapitulate: In the study of organized beings we find three principal departments, their anatomy, their physiology, and their psychology. Their anatomy deals with their forms, and with the forms of their parts; and these forms furnish in general complete data for their classification. Physiology treats of the peculiarly modified chemical action by which food is assimilated and made part of the living structure, and by which the various secretions are formed. And were not this a much higher and more difficult inquiry than the study of the forms, we might doubtless classify all plants and animals by the chemical likenesses and differences of their tissues and secretions. At present these characteristics are used in classification only as confirmations of the accuracy of the results obtained by form. Psychology deals with the souls of organized beings, with those principles that guide the chemical and mechanical forces in matter to the formation of the organism. The classification of organized beings by their forms is, in fact, in one sense, a classification by their souls by the psychical principles which are empowered to create the forms. But these unconscious souls have other functions than the creation of forms; they have besides this intellectual work, a sort of moral quality by which they select peculiar food and form peculiar products, and by which also they are aquatic or terrestrial, tropical, tender, hardy, arctic or alpine, &c. Then in animals we have, either in the same soul or in a second one, consciousness added to life, the powers of thought and feeling, desire and volition, and of knowing that they think, feel, desire and will, and these powers culminate on earth in the human race.

Matter is a storehouse of forces; in each atom slumber or rage the forces of attraction and repulsion, and also the moral qualities of chemical difference and identity. These forces, whether chemical or mechanical, act according to fixed laws, and tend towards a state of rest and of stable equilibrium. And they are all so correlated that each of them can be referred as forces, to one common unit, and shown to be capable of lifting such a weight so many feet a second.

But organized beings push always into motion, and their tissues and secretions are usually such that, in air of the same temperature and moisture as that in which they grew, they will rapidly decay the moment that life is gone. They are perhaps in chemical equilibrium; but it can hardly be called stable,—at least it is not stable enough to resist the very heat and atmospheric influences under which it was built. Yet there is no trace of any force in the organism thus compelling the forces of inorganic matter to act in this peculiar way, so different from their behavior when the organizing life is wanting.

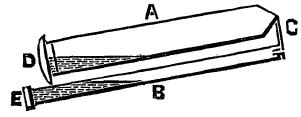
The intellectual power of the unconscious soul is not a force that can be compared with gravity, it cannot be measured by that unit; it does not act by attraction and repulsion, but simply guides (we know not how) the forces which do thus act—it rules them by moral or intellectual, not by corporeal power. The souls of plants and animals have a certain lordship over the earth, and the earth obeys their rule to a certain extent. This lordship is exercised in part involuntarily and unconsciously, that is in the phenomena of nutrition and growth; and in part consciously, in the phenomena of voluntary thought and motion and action. And had we sufficient knowledge of the habits of animals, we could doubtless classify them according to their voluntary life.

But in classifying organized beings, we do not find ourselves imposing law upon the series of species, but discover it already impressed upon them. Not only does the soul of the single organism develop thought, but in the whole gradations of the universe, from the chemical atoms up to the highest orders of mammalia, we find the development of more extensive thoughts; as though the whole universe had a soul; developing it as the soul of the violet develops its forms and color and odor. Now does this soul of the universe act consciously or unconsciously? Shall we take the vegetative power, or the conscious mind, as the type of the Deity? In endeavoring to find a symbol for the Highest in the universe, shall we look for the light of analogy into what is highest in ourselves, the conscious soul? or into what we have in common with the seaweed, the organizing power of life?

To me the answer is evident, that the highest of which we are conscious is the best symbol by which to speak of the Highest who is above our consciousness. Looking thus at the Divine Being as the Lord, who has consciously expressed His thoughts in the material world, that world becomes glorified and glows with heavenly splendor. Natural science becomes the study of the autograph works of an Infinite Author; and natural history—which is the highest of the series of physical sciences, and links them to the sciences that deal with the human mind and the works of man—becomes the means of communion with the highest geometrical, algebraical and chemical thought, which the Father of men has as yet revealed to us; and also becomes through the study of the instincts and reason of animals the fittest of all natural preparations for a study of ourselves, and of our own relations to the All wise and All good.

SIR W. THOMSON'S NEW DEPTH GAUGE.

Sir William Thomson has very recently patented another depth gauge which, though it depends upon capillary action, does not require the co-operation of chemical change. In fact, it operates by capillary action alone. The accompanying figure will illustrate the principle of this new device. Here A and B are two



glass tubes of different diameters united by a capillary tube C. The narrower tube, B, is closed at the end by a plug E, which can be removed at will: and the wider tube A is covered by a sheet of cotton cloth. This cloth acts as a porous septum which, when wetted, is permeable by water but impervious to air. For according to a law of hydrostatics, a film of water in a hole resists a difference of air pressure on its two sides, equal to the hydrostatic pressure due to a column of water in a capillary tube of the same diameter as the narrowest part of the hole. Thus it is that damp linen is impervious to air, and wet sails resist the wind much better than dry ones, as every sailor knows.

When this arrangement is lowered into the sea, water forces its way into the tube E, and the quantity forced into it during the descent becomes an indication of the depth when the relative capacities of the tubes are properly adjusted. In raising the apparatus the water